



## Effect of Cohesive Law Parameters on Instability of Crack Growth

Goutianos, Stergios; Sørensen, Bent F.

*Publication date:*  
2018

*Document Version*  
Peer reviewed version

[Link back to DTU Orbit](#)

*Citation (APA):*

Goutianos, S., & Sørensen, B. F. (2018). *Effect of Cohesive Law Parameters on Instability of Crack Growth*. Abstract from ESMC 2018 – 10th European Solid Mechanics Conference, Bologna, Italy.

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

# Effect of Cohesive Law Parameters on Instability of Crack Growth

Bent F. Sørensen<sup>1</sup>, Stergios Goutianos<sup>1</sup>, Helmuth Toftergaard<sup>1</sup>

<sup>1</sup>Department of Wind Energy, Technical University of Denmark, Roskilde, Denmark

E-mail: bsqr@dtu.dk, gout@dtu.dk, heto@dtu.dk

*Keywords: Crack instability, cohesive law, fracture resistance*

In many materials, like fibre composites where the occurrence of crack bridging during crack growth results in a large-scale fracture process zone, non-linear fracture mechanics, e.g. cohesive zone modelling [1], should be used. The fracture process zone is represented by surface tractions along the crack faces and the relationship between the local traction,  $\sigma$ , and local opening,  $\delta$ , is considered as a material property called cohesive law,  $\sigma(\delta)$ .

Crack bridging raises the fracture resistance (R-curve behaviour [2]), up to a maximum value, steady-state ( $J_{ss}$ ), when the end opening ( $\delta^*$ ) of the fracture process zone attains the critical separation,  $\delta_o$ , and therefore  $\sigma(\delta_o) = 0$ . Attainment of the steady-state fracture resistance is possible for steady-state specimens. Most practical applications, however, do not meet this requirement. After the onset of fracture, the fracture can be initially stable, but then transform to unstable fracture. The instability depends on both the cohesive/bridging law and the load and structure. Unstable fracture usually occurs before steady state fracture resistance is reached.

A criterion for the instability can be expressed in terms of the cohesive law  $\sigma(\delta)$  [4]. This is analogous to Hutchinson and Paris [3] who analysed the stability of a growing crack in an elastic-plastic solid using the J integral approach. The crack stability criterion is given by:

$$\frac{\partial J / \partial \alpha}{\partial \delta^* / \partial \alpha} \leq \sigma(\delta^*) \quad (1)$$

where J is the energy released per unit cracked area and  $\alpha$  is the crack length. This stability criterion can be used as a guide on how to modify the cohesive law parameters e.g. peak stress, critical separation and shape (material optimisation) in order to delay or even prevent the onset of unstable crack growth leading to safer designs.

As an example of application of the stability criterion, a DCB specimen loaded with forces or displacements will be presented. It will be shown, that by changing these parameters, a more controlled crack growth can be obtained.

## References

- [1] Dugdale, D.S. "Yielding of steel sheets containing slits", *Journal of the Mechanics and Physics of Solids*, **Vol 8**, page 100-104 (1960).
- [2] Suo, Z., Bao, G., and Fan, B., "Delamination R-curve phenomena due to damage", *Journal of the Mechanics and Physics of Solids*, **Vol 40**, page 1-16 (1992).
- [3] Hutchinson, J. and Paris, P., "Stability Analysis of J-Controlled Crack Growth" in *Proceedings of Elastic-Plastic Fracture*, West Conshohocken, PA, page 37-64 (1979).
- [4] McGugan, M., Pereira, G., Sørensen, B.F., Toftergaard, H., and Branner, K., "Damage tolerance and structural monitoring of wind turbine blades", *Philosophical Transactions A*, **Vol 373**, Article Number: 20140077 (2015).